

PRE-FILLED SAFETY DILUENT INJECTOR

JOHN M. BARKER
THOR HALSETH
JOSEPH KOVALSKI
ROBERT MCWETHY
BERNARDO CHALLIOL

PRIORITY CLAIM

This application claims priority to U.S. Provisional Application No. 60/275,568, filed March 13, 2001, which is hereby incorporated herein by reference.

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FIELD OF THE INVENTION

The present invention relates to medical devices and more particularly to medical devices having a cartridge with two chambers that store separate components of a medication and allow the components to be mixed and subsequently injected into a patient.

BACKGROUND

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Pre-filled syringes store and allow for mixing of separate medicinal components. Many of these syringes, sometimes called "mixing syringes," store a first component in one compartment and a diluent or a second component in a second compartment. These syringes allow the two components to be stored separately until just before the syringe is used, at which time the components can be mixed within the syringe and immediately injected into a patient.

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Pre-filled mixing syringes are advantageous for many types of pharmaceuticals. Some medications, like antibiotics, vitamins and hormones,

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must be packaged and stored in component parts to enhance shelf life. These medications may need to be stored as a powdered component and a diluent, or as a separate pair of solutions. Pre-filled mixing syringes allow medications to be stored in component parts right up until the medication is injected. In addition, pre-filled mixing syringes eliminate the burden of measuring medicinal components and mixing diluents from separate containers.

Despite these advantages, prior mixing syringes have not offered reliable safety features to protect the syringe user from accidental needle sticks following injection. In particular, prior syringe assemblies have not provided a mixing syringe that operates integrally with an injection needle that can be automatically shielded upon completion of the injection.

SUMMARY OF THE INVENTION

With the foregoing in mind, the present invention provides a pre-filled medical device for mixing separate components of a medication and injecting the medication into a patient. The device includes a two-chambered container, such as a cartridge, connected to a needle that retracts automatically after use. After retraction, the contaminated needle tip is enclosed within the device to prevent inadvertent needle sticks.

The device includes a hollow barrel surrounding the needle and having a generally open rearward end that forms a socket. A two-chambered cartridge containing component parts of a medication is adapted to engage the socket. Prior to use, the components are stored separately in the two cartridge chambers. During use, a plunger disposed in the rearward end of the cartridge is advanced into the cartridge to combine the two components in one chamber for mixing. Subsequent pressure on the plunger advances the medicinal mixture through the needle into a patient.

The injection needle is operable between an extended position and a retracted position. In the extended position, the forward tip of the needle projects forwardly from the barrel. In the retracted position, the forward tip is enclosed within the barrel. When the needle is in the extended
5 position, a biasing element biases the needle toward the retracted position. A needle retainer releasably retains the needle in the extended position against the force of the biasing element. During the injection stroke, the cartridge disengages the needle retainer to allow the biasing element to propel the needle rearwardly into the barrel.

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DESCRIPTION OF THE DRAWINGS

The foregoing summary as well as the following detailed description of the preferred embodiments will be best understood when read
15 in conjunction with the following drawings, in which:

Fig. 1 is perspective view of a pre-filled cartridge injector having a two-chambered container that stores component parts of a medication;

20 Fig. 2 is an exploded perspective view of the cartridge injector shown in Fig. 1;

Fig. 3 is an enlarged view of a locking clip of the cartridge injector shown in Fig. 2;

25 Fig. 4 is a sectional view of the cartridge injector shown in Fig. 1 taken along the line 4-4;

Fig. 5 is a sectional view of the cartridge injector shown in Fig. 4 taken along
30 the line 5-5;

Fig. 6 is a sectional view of the cartridge injector shown in Fig. 1, illustrating the device prior to mixing the component parts of the medication;

5 Fig. 7 is a sectional view of the cartridge injector shown in Fig. 1, illustrating the device after mixing with the cartridge locked to impede injection;

Fig. 8 is a sectional view of the cartridge injector shown in Fig. 1, illustrating the device after mixing the cartridge unlocked to allow injection;

10 Fig. 9 is a sectional view of the cartridge injector shown in Fig. 1, illustrating the device, after injection, just prior to needle retraction;

Fig. 10 is a sectional view of the cartridge injector shown in Fig. 1, illustrating the device after needle retraction.

15 Fig. 11 is an enlarged fragmentary sectional view of the cartridge injector shown in Fig. 1, illustrating the tamper resistant connection between the cartridge and barrel after the needle is retracted.

20 Fig. 12 is a sectional view of a second embodiment of a two-chambered pre-filled cartridge injector having a retractable needle.

Fig. 13 is a sectional view of the device shown in Fig. 12 taken along the line 13-13.

25 Fig. 14 is a sectional view of the device shown in Fig. 12 illustrating the device during mixture of the medicinal components in the cartridge transfer of one component of medicine between chambers.

30 Fig. 15 is a sectional view of the device shown in Fig. 12 illustrating the device after mixture of the medicinal components.

Fig. 16 is a sectional view of the device shown in Fig. 12 illustrating the device after needle retraction.

5 Fig. 17 is a sectional view of a third embodiment of a two-chambered pre-filled cartridge injector having a retractable needle.

Fig. 18 is a sectional view of the cartridge portion of the device illustrated in Fig. 17.

10 Fig. 19 is a sectional view of the device shown in Fig. 17 illustrated without the cartridge, illustrated prior to use.

15 Fig. 20 is a sectional view of the cartridge in Fig. 18 illustrating the device during mixture of the medical components.

15 Fig. 21 is a sectional view of the device shown in Fig. 18 illustrating the device after mixture of the medical components.

20 Fig. 22 is a sectional view of the device shown in Fig. 17 illustrating the device at the completion of an injection.

Fig. 23 is a sectional view of the device shown in Fig. 17 illustrating the device after needle retraction.

25 Fig. 24 is an exploded perspective view of a fourth embodiment of a two-chambered pre-filled cartridge injector having a retractable needle.

Fig. 25 is a sectional view of the device illustrated in Fig. 24.

30 Fig. 26 is a sectional view of the device in Fig. 24 illustrating the device after mixture of the medical components.

Fig. 27 is a sectional view of the device shown in Fig. 24 illustrating the device at the completion of an injection.

5 Fig. 28 is a sectional view of the device shown in Fig. 24 illustrating the device after needle retraction.

Fig. 29 is a sectional view of the device shown in Fig. 24 illustrating the device after needle retraction.

10 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to the figures in general, and to Figs. 1-11 specifically, an injector device **10** is shown with a needle **12** having a sharpened distal tip **16** for insertion into a patient. As shown in Fig. 4, the injector device **10** has an attached cartridge **50** having a first chamber **52** and a second chamber **56**. The two chambers **52, 56** are pre-filled with component parts of a medication that are to be mixed prior to injection. The cartridge **50** also includes a plunger **40** that is slidable within the cartridge. Initially, advancing the plunger **40** in the cartridge **50** expels the medicinal component from the first chamber **52** into the second chamber **56** to mix the two medicinal components. After mixing the components, advancing the plunger drives the cartridge forwardly to inject the medicine into a patient. Upon completion of the injection stroke, the medical professional releases pressure from the plunger to allow automatic retraction of the needle **12** into the device **10** to protect the contaminated needle **12** from inadvertent contact.

25 The injector device **10** includes a double-ended needle **12**, a generally cylindrical barrel **30**, a compression spring **26** and a needle retainer **20** releasably retaining the needle against the bias of the spring. As shown in Figs. 4 and 5, the needle **12** has a sharpened proximal tip **14** and a sharpened distal tip **16**. The spring **26** circumscribes the needle **12** and is compressed against the interior of the barrel **30** at the barrel's distal end. The

rearward end of the spring 26 bears against the interior of the needle retainer 20 to bias the needle 12 and needle retainer in the rearward direction.

5 The needle 12 is operable between two positions, an extended position and a retracted position. In the extended position, the needle 12 projects forwardly from the forward end of the barrel 30. In the retracted position, the needle 12 is retracted into the barrel 30 so that the sharpened tip 16 of needle 12 is enclosed within the barrel to prevent inadvertent contact
10 with the sharpened tip. When the needle is in the extended position, the spring 26 biases the needle 12 rearwardly toward the retracted position. The needle retainer 20 releasably retains the needle 12 in the extended position, against the bias of the spring 26. During the injection stroke, the cartridge 50 cooperates with the needle retainer 20 to allow the needle to retract into the
15 barrel 30, as shown in Fig. 10.

Referring now to Figs. 5-7, the cartridge 50 includes a first chamber 52 containing a first medicinal component 54 and a second chamber 56 containing a second medicinal component 58. The chambers 52, 56 are separated by a mid wall 60 containing an orifice 62. A rear seal 70 seals the first chamber 52 to prevent the components from being mixed prior to use. When the rear seal 70 is pierced and the plunger 40 is advanced into the cartridge 50, the first component 54 flows into the second chamber 56 through the orifice 62, where it combines with the second component 58 to form the medication 59, as shown in Figs. 6-7. Subsequent pressure on the plunger 40 and cartridge 50 forces the medication 59 through the needle 12 and into the patient.
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Referring now to Figs. 4-6, the elements of the injector device
30 10 will be described in greater detail. The barrel 30 is generally cylindrical and the distal end of the barrel has a tapered nose 32. The nose 32 has an

opening through which the needle 12 extends so that the sharpened tip 16 of the needle can be inserted into a patient. The rearward end of the barrel 30 is open, forming a cylindrical socket 34 adapted to receive the cartridge 50. Two laterally extending flanges 36 project outwardly from the barrel 30, 5 transverse the longitudinal axis of the barrel, forming a pair of finger grips for operating the device 10. The barrel 30 further includes a pair of retaining apertures 38 and a pair of lockout windows 39 that cooperate with the needle retainer 20 as described further below.

10 As shown in Fig. 5, a hub 21 projects from the rearward end of the needle retainer 20. The hub 21 is a generally cylindrical element having a central bore 23. The needle 12 is disposed within the central bore 23 of the hub 21 so that the rearward end 14 of the needle 12 projects rearwardly from the hub and the forward end 16 of the needle projects forwardly from the hub. 15 The needle 12 can be attached to the hub 21 in one of several ways. For example, the needle 12 can be attached to the hub 21 by an adhesive such as a UV curable adhesive. Alternatively, the needle 12 can be molded into the hub 21, which is formed of plastic. The rearward end of the hub 21 includes a circumferentially barbed connector 25 configured to cooperate with 20 the cartridge 50 to connect the cartridge to the needle hub 21 as discussed further below.

The needle retainer 20 is axially displaceable within barrel 30 to facilitate needle retraction. The needle retainer 20 can be molded out of a rigid, high strength resin, such as polycarbonate. Prior to retraction, the needle retainer 20 is maintained in a fixed axial position while the medication 25 59 is expelled from the cartridge 50. After the injection, the needle retainer 20 and the attached needle 12 are displaced rearwardly by the compression spring 26.

30 The spring 26 is a compression spring and may be formed of stainless steel, treated carbon steel wire or other suitable non-corrosive

spring metal. The residual compression of the spring prior to disengagement of the needle retainer is of sufficient magnitude to facilitate complete needle retraction and overcome the frictional resistance between sliding components within the device 10.

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Referring now to Fig. 6, the needle retainer 20 includes a pair of retaining arms 22 that extend radially outwardly and forwardly from the distal end of the needle retainer 20. During operation, the needle retainer 20 is operable between a locked position and an unlocked position. In the locked position, the retaining arms 22 engage the retaining apertures 38 in the barrel wall to maintain the needle in a fixed axial position with the forward tip 16 of needle 12 projecting forwardly from the barrel 30. More specifically, in the locked position, the retaining arms 22 engage the barrel 30 to hold the needle hub 21 and needle 12 against the rearward bias of the spring 26. In the unlocked position, the retaining arms 22 are positioned so as to allow the needle hub 21 and needle 12 to be retracted rearwardly. More specifically, in the unlocked position, the retaining arms 22 are disengaged from the retaining apertures 38, allowing the spring 26 to propel the needle hub 21 and needle 12 rearwardly.

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As discussed above, the retaining arms 22 on the needle retainer 20 project forwardly and outwardly into engagement with the retaining apertures 38 in the wall of the barrel 30. The terminal end of each arm forms a retaining tab 24 that is configured to project into a retaining aperture 38. More specifically, the retaining tabs 24 engage the lip formed by each retaining aperture 38 in the wall of the barrel 30. In this way, the retaining tabs 24 operate as a pair of latches to retain the needle hub 21 and needle 12 against the rearward bias of the spring.

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Referring again to Figs. 4 and 5, the cartridge 50 is a generally cylindrical vessel that may be molded out of pharmaceutical quality glass

such as borosilicate, or a rigid inert plastic such as polyolefin or polyester. The midwall **60** that separates the first and second chambers may be formed of a rigid inert plastic such as polyolefin or polyester. The barrier or midwall **60** can be molded as part of the cartridge **50** or bonded to the inside wall of
5 the cartridge. Each chamber is filled with a predetermined amount of a medication during manufacturing of the device **10**.

The front end of the forward chamber **56** is sealed by an
10 elastomeric front seal **80**, which may be molded in a self-sealing biocompatible elastomer such as polyisoprene. The front seal **80** is generally cylindrical, having a plurality of axially-spaced circumferential ribs **81**. The
15 ribs **81**, which are more clearly shown in Fig. 2, frictionally and sealingly engage the interior of the container to provide a fluid tight seal, thereby preventing fluid from leaking from the cartridge **50**. The front seal **80** also has a front end that is pierceable by the rearward sharpened tip **14** of needle **12**. After being pierced, the front end of the front seal **80** reseals around the
needle **12** to prevent fluid from leaking from the cartridge **50**.

Referring now to Figs. 5 and 6, the front seal **80** has a socket **82**
20 configured to cooperate with the barbed connector **25** on the needle hub **21**. The socket **82** includes two radially relieved recesses, **82a** and **82b**, that mate with the barbed connector **25**. Specifically, the barbed connector **25** matingly engages the front seal **80** in a first position and a second position.

In the first position, the barbed connector **25** engages the first
25 recess **82a**, as shown in Fig. 5. In this position, the cartridge is attached to the hub, but the rearward end of the needle does not pierce the front seal **80**. Applying pressure to the plunger **40** displaces the cartridge forwardly relative to the hub, thereby displacing the barb into to the second position. In the
30 second position, the barbed connector **25** engages the second recess **82b**, as shown in Fig. 6. In this position, the rearward end of the needle **12** pierces

the front seal 80.

The front seal 80 includes a hollowed cavity 84 at its rearward end. In this way, a pierceable wall 86 is formed in the front seal 80 between the cavity 84 and the second recess 82b. As shown in Fig. 5 prior to use, the cartridge 50 is mounted in the first position so that the barbed connector 25 engages the first recess 82a. In this position, the needle 12 does not penetrate the pierceable wall 86. As the hub 21 is displaced from the first position to the second position, the rearward end 14 of the needle 12 pierces the wall 86 and extends into the cavity 84 as shown in Fig. 6. The cavity 84 opens into the interior of the second chamber 56 of cartridge 50 so that when the needle 12 projects into the hollowed section 84, the needle is in fluid communication with the interior of the cartridge. After the needle 12 penetrates the pierceable wall 86, the wall reseals around the needle to form a fluid-tight seal and prevent medication in the cartridge 50 from leaking around the needle.

To prepare the injection device 10 for use, the medical professional displaces the cartridge 50 forwardly relative to the needle retainer 20, so that the forward seal 80 is driven over the barbed connector 25, such that the barbed connector engages the second recess 82b. At the same time, the proximal tip 14 of needle 12 pierces the pierceable wall 86, so that the needle is in fluid communication with the second chamber, as shown in Fig. 6.

The connection between the front seal 80 and the needle hub 21 is preferably a one-way engagement. In other words, when the front seal 80 is mounted on the barbed connector 25, the cartridge 50 can be displaced forwardly relative to the barbed connector, but the cartridge cannot be displaced rearwardly relative to the barbed connector. In this way, the cartridge 50 cannot be readily removed from the needle hub 21 in barrel 30,

such that the cartridge is substantially permanently attached to the needle hub and barrel.

The one-way connection is facilitated by the rearward-facing tapered shoulder of the barbed connector 25 and the square shaped forward-facing shoulder of the barbed connector. In particular, the rearward-facing shoulder of the barbed connector 25 cooperates with tapered sides in the first and second radial recesses 82a and 82b to permit relative displacement of the plug from the first recess to the second recess. Reverse displacement from the second recess 82b back to the first recess 82a is resisted by the square shaped forward-facing shoulders on barbed connector 25, which act to impede reverse displacement.

Referring now to Fig. 4, the front seal 80 is configured to prevent ejection of fluid when the barbed connector 25 is displaced from the first position, in which the barbed connector 25 engages the first radial recess 82a, to the second position, in which the barbed connector engages the second radial recess 82b. Specifically, the front seal 80 includes a flared head 88 or circumferential flange at the forward end of the front seal. The open distal end of the cartridge 50 terminates with a beaded rim 51 that seats against the rearward edge of the flared head 88. The outside diameter of the flared head 88 is greater than the inside diameter of the open distal end of the cartridge 50, thereby impeding rearward displacement of the front seal 80 into the cartridge when force is initially applied to the plunger 40. In addition, the force required to overcome the frictional engagement between the outer circumference of the front seal 80 and the inner wall of the cartridge 50 is greater than the force required to displace the plug 25 from the first recess 82a to the second recess 82b. Accordingly, when force is initially applied to the plunger 40, the front seal 80 remains in a fixed position relative to the cartridge 50, while the barbed connector 25 is displaced into the second position. This restriction on the front seal 80 limits the release of fluid from

the cartridge 50 when the needle 12 pierces the wall 86.

During storage of the injection device 10, the medication is divided into two separate components stored in the cartridge 50, as shown in Fig. 5. Specifically, a first component 54 of the medicine is stored in the rear chamber 52 and a second component 58 of the medicine is stored in the forward chamber 56. The two chambers are separated by the mid-wall 60 containing an orifice 62 and a hollow piercing member 64 mounted in the orifice. The orifice 62 is located axially at the center of the midwall 60. In addition, a small vent hole 63 is located just off center in the midwall 60 to vent the air from the dead space area between the mid wall and the mid seal 70. Preferably, the piercing member 64 is fabricated out of suitable non-corrosive material such as stainless steel or treated carbon steel wire. When the plunger 40 is axially advanced in the cartridge 50, the first component 54 in the rear chamber 52 advances through the piercing member 64 and into the forward chamber 56 to combine with the second component 58.

Prior to use of the injection device 10, fluid communication between the first and second chambers is prevented by an elastomeric mid seal 70, which may be molded in a self-sealing biocompatible elastomer such as polyisoprene. The mid seal 70 is initially slidably disposed in the first chamber 52 between the piercing member 64 and the first component 54, as shown in Figs. 4-5. The mid seal 70 is generally cylindrical, having a plurality of axially-spaced circumferential ribs 71, as shown more clearly in Fig. 2. The ribs 71 frictionally and sealingly engage the inner wall of the cartridge 50 to provide a fluid-tight seal. This fluid-tight seal prevents fluid in the first chamber from entering the piercing member 64. The mid seal 70 also includes a hollowed section 72 formed in the forward end of the mid seal that opens to the first chamber 52 at the rearward end of the mid seal. The forward end of the mid seal 70 is closed by a membrane 78 that is pierceable by the piercing member 64. Upon piercing the membrane 78, fluid

communication is established between the first and second chambers to allow the first and second components of the medication to be mixed.

Like the front seal 80 and mid seal 70, the plunger 40 is generally cylindrical, preferably having a plurality of axially-spaced circumferential ribs 41. The plunger 40 may be molded in a self-sealing biocompatible elastomer such as polyisoprene. Alternatively, the plunger 40 could be a two-part assembly in which a cylindrical elastomeric seal is mounted to a rigid plastic plunger rod. The ribs 41, which are more clearly shown in Fig. 2, frictionally and sealingly engage the interior of the cartridge 50 to provide a fluid tight seal, thereby preventing fluid from leaking from the proximal end of the cartridge.

The plunger 40 is slidable within the first chamber 52 in response to pressure applied to the thumb pad 42. When the plunger 40 is axially advanced into the cartridge 50, the first component 54 is compressed against the rearward end of the mid seal 70 in the first chamber 52. As back pressure on the mid seal 70 overcomes the frictional resistance between the mid seal and the cartridge 50, the mid seal is displaced into the piercing member 64 until the membrane 78 is pierced, as shown in Fig. 6. As the mid seal advances, air from the space between the mid seal and mid wall vents through the vent hole 63 in the mid wall. At such time, the piercing member 64 penetrates through the hollowed section 72 to connect the first chamber 52 and second chamber 56 in fluid communication.

After the mid seal 70 is pierced, pressure applied to the plunger 40 advances the first component 54 through the piercing member 64 and into the second chamber 56 where the first and second components are subsequently mixed to form the medication 59. The plunger 40 is displaced forwardly relative to the first chamber 52 until the flanged portion of the thumb pad 42 contacts the proximal end of the cartridge 50, as shown in Fig. 7. The

outside diameter of the thumb pad 42 is larger than the inside diameter of the cartridge 50, thereby preventing further displacement of the plunger 40 once the thumb pad contacts the proximal end of the cartridge 50. Preferably, the distance between the forward end of the plunger 40 and the rearward end of the mid seal 70 is equal to the distance between the flanged portion of the thumb pad 42 and the proximal end of the cartridge 50. Once the thumb pad 42 contacts the proximal end of the cartridge 50, the plunger is fixed relative to the cartridge 50. At this point, axial advancement of the cartridge 50 relative to the barrel 30 is restricted, as described in more detail below.

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Preferably, the injection device 10 includes a locking mechanism for preventing accidental release of the contents in the second chamber prior to mixing the two components. In the present embodiment shown in Fig. 7, the barrel 30 includes a locking clip 100 in the barrel wall to prevent accidental discharge of the medicinal components. The wall of the barrel 30 includes a pair of radial slots 104 formed in a plane that is transverse the longitudinal axis of the barrel. When the locking clip 100 is inserted through the slots 104, the clip prevents inadvertent forward displacement of the cartridge 50 relative to the front seal 80, thereby preventing accidental advancement of the medicinal components through the needle 12. The locking clip 100 is preferably formed of a resilient high strength and high modulus resin, such as acetyl or polycarbonate, and is configured to releasably engage the slots 104 in the barrel 30.

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Referring to Figs. 1-3, the locking clip 100 is preferably a flat member having a pair of resiliently deflectable legs 101 that join to form a U-shape. The open end of the locking clip 100 has tapered edges 102 that allow the legs 101 to deflect outwardly as the locking clip 100 is inserted into the sidewall of the barrel 30. In addition, the locking clip 100 has a plurality of teeth 103 on the inside edge of the legs 101 that are adapted to engage the edges of radial slots 104.

As the locking clip is inserted into the sidewall of the barrel 30, the legs 101 deflect outwardly to allow the teeth 103 to clear the edges of radial slots 104. Upon being deflected outwardly, the resilience of legs 101 bias the legs radially inwardly toward their original position. Once the teeth 103 are disposed within the slots 104, the legs 101 deflect radially inwardly toward their original position and releasably engage the outer edges of the needle retainer 20 in barrel 30. In the inserted position, the closed end of the locking clip 100 remains outside the barrel 30, as shown in Figs. 1 and 4.

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After the medicinal components are mixed within the cartridge, the locking clip 100 is removed to permit injection of the medicine 59, as shown in Fig. 8. The locking clip 100 is removed from the barrel 30 by pulling the closed end of the clip in a direction transverse to the longitudinal axis of the barrel. This direction is marked "A" in Fig. 1. By pulling the clip in this manner, the legs 101 are deflected outwardly from the slots 104 to allow the teeth 103 to clear the edges of slots 104.

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After the locking clip 100 is removed from the barrel 30, the medication 59 is injected into the patient by advancing the cartridge forwardly into the barrel. Pressure applied to the thumb pad 42 causes the plunger 40 and cartridge 50 to move forwardly relative to the barrel 30. With the barbed connector 25 mounted in the second recess 82b in the front seal 80, the front seal remains stationary while the cartridge 50 is advanced forwardly, as shown in Fig. 9. The front seal 80 and flared head 88 are configured to form a sliding fit with the interior of the cartridge 50 so that the cartridge can slide over the front seal. As the cartridge 50 is advanced, the mid seal 70 and the mid wall 60 are displaced toward the front seal 80. This causes a reduction of volume in the second chamber 56, whereby the medication is displaced into the needle to facilitate the injection. At the completion of the injection, the mid wall 60 bears against the rearward end of the front seal 80, as shown in Fig.

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Referring now to Figs. 9-10, the automatic retraction of the needle **12** shall be described. The cartridge **50** is axially advanced to the proximal end of the barrel **30** until the medication **59** is completely expelled from the second chamber **56**. As the cartridge **50** is advanced, the beaded circumferential rim **51** of the cartridge is displaced into engagement with the retaining arms **22** of needle retainer **20**. Preferably, the cartridge **50** is configured so that the longitudinal distance between the rearward end of the front seal **80** and the mid wall **60** corresponds to the longitudinal distance between the circumferential rim **51** of the cartridge and the retaining arms **22** when the cartridge is mounted on the barbed connector **25** in the second position. In this way, the rim **51** of the cartridge **50** engages the retaining arms **22** when substantially all of the medication **59** is expelled from the device **10**.

After the rim **51** of cartridge **50** engages the retaining arms **22**, continued axial advancement of the cartridge deflects the retaining arms radially inwardly so that the retaining tabs **24** are displaced inwardly, as shown in Fig. 9. In the inward position, the retaining tabs **24** are disengaged from the retaining apertures **38** of the barrel **30**. In this way, the cartridge **50** operates as an actuator, such that axial advancement of the cartridge displaces the needle retainer **20** into an unlocked position. In the unlocked position, the needle retainer **20** is no longer locked in place against the force of the spring **26**. After the needle retainer **20** is in the unlocked position and the user releases pressure on the plunger **40**, the spring **26** propels the needle **12** rearwardly until the sharpened distal tip **16** of the needle is enclosed within the barrel **30**.

As shown in Fig. 10, when the needle **12** is retracted, the needle, needle retainer **20** and cartridge **50** are displaced rearwardly

together. During retraction, the retaining arms **22** are biased radially outwardly so that the retaining tabs **24** ride along the inside wall of the barrel. The force of the spring **26** is sufficiently strong to overcome the frictional resistance generated between the guide arms **28** and the barrel **30**.

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Preferably, the injection device **10** includes a mechanism for limiting rearward displacement of the retracted elements. Referring now to Figs. 2, 4 and 10, the needle retainer **20** includes a pair of guide arms **28** that cooperate with a pair of alignment channels or grooves **31** formed in the interior wall of the barrel **30**. The guide arms **28** may be molded out of a rigid, resilient high strength resin, such as polycarbonate. The guide arms **28** extend forwardly from the needle retainer **20** and project radially outwardly into engagement with the alignment grooves **31**.

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15 Each guide arm **28** includes a linear elongated rear portion which preferably is generally parallel to the longitudinal axis of barrel **30**. The forward portion of each guide arm **28** bends outwardly transverse to the longitudinal axis of the barrel **30** and extends into one of the alignment grooves **31**. When the needle retainer **20** is disposed within the barrel, the guide arms **28** are deflected radially inwardly from their natural state. In this position, the guide arms **28** are biased radially outwardly against the inner wall of the barrel **30** due to the resilient properties of the guide arms.

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25 The forward ends of guide arms **28** are preferably contained within the alignment grooves **31** to substantially limit rotation of the needle and needle retainer **20** during needle retraction. This engagement ensures that the guide arms are aligned with the lockout windows **39** so that the guide arms snap into the lockout windows at the end of retraction. In this way, the needle retainer **20** is limited to axial displacement during needle retraction.

30 During retraction, the frictional resistance between the forward ends of the guide arms **28** and the inside wall of the barrel **30** is overcome by the

expansion force of the spring **26**.

As shown in Fig. 4, the linear elongated rear portion of each guide arm **28** is spaced radially inwardly from the inner wall of the barrel **30** to create a clearance space between the linear portion of the guide arms and the barrel. Preferably, the minimum radial thickness of the clearance space is greater than the thickness of the wall of the cartridge **50** or the cartridge rim **51**. In this way, when the cartridge **50** is advanced forwardly to disengage the retaining arms **22**, advancement of the cartridge will not be impeded by the guide arms **28**.

Each alignment groove **31** is substantially parallel to the longitudinal axis of the barrel **30**. In Fig. 4, the groove **31** is shown extending to rearward end of the barrel. However, it may be desirable to terminate the groove forward of the rearward end of the barrel. The rearward portion of each alignment groove **31** intersects a lockout window **39** formed in the wall of the barrel **30**. The lockout windows **39** are adapted to receive the forward ends of the guide arms **28**, as shown in Fig. 10. In particular, as the front end of each guide arm **28** aligns with the corresponding lockout window **39** during needle retraction, the radially outward bias of the guide arm displaces the arm outwardly so that the forward end projects into the lockout window. The engagement between the guide arms **28** and lockout windows **39** prevent further axial movement of the retainer **22**. As a result, the retracted elements are limited from further displacement in the forward or rearward direction.

Preferably, the injection device **10** includes a mechanism to limit tampering or removal of the cartridge **50** from the barrel socket **34**. Referring now to Fig. 11, the present embodiment includes an annular lip **35** that projects radially inwardly from the inside wall of the socket **34** in barrel **30**. The lip **35** is adapted to seat against the beaded rim **51** on the cartridge **50** so

that the cartridge can not be easily pulled out of the rear of the barrel 30. As a result, access to the retracted elements, and the contaminated needle in particular, is limited.

5 Referring now to Figs. 4-10, the operation of the injection device 10 will be described. Prior to use, the needle 12 is disposed in an extended position so that the distal end 16 of the needle projects forwardly from the barrel 30, as shown in Fig. 4. Preferably, the device 10 is shipped with the cartridge 50 already mounted in barrel 30 so that the barbed connector 25 is
10 engaged in the first recess 82a. Alternatively, the cartridge 50 may be shipped separately from the barrel 30, so that the cartridge must be attached to the barrel prior to use.

15 With the cartridge 50 and barrel 30 assembled, the device 10 is held vertically so that the distal end 16 of needle 12 points upwardwardly. The user holds the device 10 by placing the user's thumb in a supporting position beneath the thumb pad 42 of plunger 40. In addition, the user places a finger over each finger grip 36 to control the operation of the device 10.
20 With the user's fingers anchored over the finger grips 36, the user applies a slight squeezing pressure on the thumb pad 42, much like a conventional syringe. The squeezing pressure displaces the cartridge 50 forwardly relative to the barrel so that the barbed connector 25 on the needle retainer 20 engages the second recess 82b in front seal 80 and the needle 12 pierces the wall 86. As the front seal 80 is pierced, entrapped air in the forward
25 chamber 56 is vented through needle 12.

30 Continued advancement of the plunger 40 drives the seal 70 toward the piercing element 64 until the piercing element pieces the mid seal, thereby providing fluid communication between the forward and rearward chambers 52, 56. At this point, the first component 54 may be advanced into the forward chamber 56. Pressure is applied on the thumb pad 42 until the

first component **54** is completely expelled from the rearward chamber **52** into the forward chamber **56** and the forward end of the plunger meets the rearward end of the mid seal **70**. The user then shakes the injector device **10** to mix the first and second components **54, 58** inside the forward chamber **56**.

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During mixing, the locking clip **100** prevents the cartridge **50** from being advanced forwardly into the needle retainer **20**. This constraint on the cartridge **50** limits the potential for inadvertent discharge of the medication **59** from the needle **12** and premature needle retraction. Once the medication **59** is adequately mixed, the user removes the locking clip **100** from the barrel **30** so that the cartridge **50** can be advanced forwardly within the barrel. At this point, initial pressure applied to the thumb pad **42** advances the cartridge and vents excess air out of the second chamber **56**.

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The needle is then inserted into a patient and the plunger **40** is depressed to axially advance the cartridge **50** relative to the barrel **30**, thereby injecting the medication **59** from the cartridge into the patient. At the end of the injection stroke, the beaded rim **51** on the cartridge **50** engages the retaining arms **22**, thereby displacing the retaining tabs **24** radially inwardly to disengage the needle retainer **20** into the unlocked position. Although the needle retainer **22** is in the unlocked position, the needle **12** does not retract until the user releases pressure from the thumb pad **42**. In this way, the user can retain pressure on the thumb pad **42** until after the needle is withdrawn from the patient. The user can then release pressure from the thumb pad **42** so that the needle is propelled rearwardly by the spring **26**. Alternatively, the user can release pressure from the thumb pad **42** while the needle **12** is still inserted in the patient. Once the thumb pad **42** is released, the spring **26** propels the needle **12** rearwardly so that the contaminated distal tip **16** of the needle is enclosed within the barrel **30**.

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Referring now to Figs. 12-16 in general, and to Figs. 12-13

specifically, a second embodiment of a pre-filled safety diluent injector is shown. The injector device 110 includes elements that are substantially similar to the elements described above in connection with the first embodiment 10, illustrated in Figs. 1-11. These elements include: a double-ended needle 112, a generally cylindrical barrel 130, a compression spring 126, a needle retainer 120 releasably retaining the needle against the bias of the spring, a locking clip 200. The needle 112 has a sharpened proximal tip 114 and a sharpened distal tip 116. The spring 126 circumscribes the needle 112 and is compressed against the interior of the barrel 130 at the barrel's forward end. The rearward end of the spring 126 bears against the interior of the needle retainer 120 to bias the needle 112 and needle retainer in the rearward direction.

In contrast to the previous embodiment, the second embodiment utilizes a cartridge 150 having a selectively sealable by-pass fluid passage 160 to separate the two medicinal components, rather than a mid wall and a pierceable seal as described above with the first embodiment. Prior to use, a mid seal 170 within the cartridge 150 separates the two medicinal components 154, 158. Prior to use, the mid seal 170 is displaced forwardly adjacent the by-pass passage 160, which provides a fluid passage, allowing the two medicinal components 154, 158 to be mixed. The mixed components can then be injected into the patient.

Referring to Figs. 12, 13, the detail of the Cartridge 150 will be described in greater detail. The cartridge is a generally cylindrical container. The forward end of the cartridge is sealed by the pierceable forward seal 180. The rearward end of the cartridge is sealed by a piston 143 that forms a fluid-tight seal with the interior wall of the cartridge. Intermediate the forward seal 180 and the piston 143, a mid seal 170 forms a fluid-tight seal with the interior wall of the cartridge, separating the cartridge into two chambers, a forward chamber 156 for receiving a first component 158, and a rearward chamber

152 for receiving a second component 154.

The cartridge 150 includes a bubble-like fluid passage 160 that protrudes outwardly from the side of the cartridge. The fluid passage 160 forms an area in which the diameter of the cartridge is greater than the diameter of the mid seal. The fluid passage 160 is an axially elongated channel having a length that is greater than the axial length of the mid seal 170, and preferably, is shorter than the combined length of the mid seal and the piston 143.

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Although the fluid passage 160 is illustrated as a bubble-like protrusion, the fluid passage may be formed in other configurations. For instance, the fluid passage may be a recess or axial groove formed in the interior wall of the cartridge 150, so that the fluid passage does not protrude from the exterior surface of the cartridge. Similarly, the fluid passage may be an annular recess formed in the interior wall of the cartridge.

Referring to Fig. 12, the device 110 is illustrated in a "storage" position. In this position, the mid seal 170 prevents the two medicinal components from mixing. Therefore, the sealed cartridge 150 can be stored for an extended period, if desired, without compromising the efficacy of the medicinal components. In the stored position, the mid seal 170 is disposed rearwardly of the fluid passage 160 so a fluid-tight seal is formed between the mid seal and the interior wall of the cartridge, around the entire circumference of the mid seal.

During storage of the injection device 110, the medication is divided into two separate components stored in the cartridge 150, as shown in Figs. 12-13. Specifically, the first component 154 of the medicine is stored in the first chamber 152 and the second component 158 of the medicine is stored in the second chamber 156. As discussed further below, preferably,

when the cartridge is being filled during manufacture, a quantity of air remains within the second chamber 156.

A plunger 140 is slidably disposed in the rearward end of the cartridge 150. The plunger 140 is comprised of a plastic molded plunger rod 141 and an elastomeric piston 143. The piston 143 forms a fluid-tight seal with the inner wall of the cartridge, and is slidably displaceable within the cartridge. The plunger rod 141 can be connected to the plunger seal 143 in a number of ways. In the present embodiment, the plunger rod 141 includes external screw threads that are configured to engage internal threads inside the plunger seal 143, whereby the plunger rod and seal can be screwed together.

Referring now to Fig. 14, the transfer of the first medicine component 154 into the second chamber 156 shall be described. The mid seal 170 is advanced axially until it registers with the fluid passage 160. The fluid passage 160 then provides a by-pass passage so that the component in the rearward chamber can be injected into the forward chamber. Since the forward chamber preferably includes a quantity of air (or other compressible fluid), the material in the forward chamber can be compressed to allow the mid seal to be advanced into registry with the fluid passage 160. Alternatively, the forward chamber may include a vent for venting the air from the forward chamber when the fluid is transferred from the rearward chamber into the forward chamber. If a vent is included, preferably the vent is sealable to prevent leakage of the mixed components during injection.

Specifically, to mix the two components in the cartridge, the plunger 140 is axially advanced into the cartridge 150, to compress the first component 154 against the rearward end of the mid seal 170 in the first chamber 152. As back pressure on the mid seal 170 overcomes the frictional resistance between the mid seal and the cartridge 150, the mid seal is

displaced forwardly in the cartridge. Once the mid seal 170 is displaced into alignment with the fluid passage 160, a passage is created between the mid seal and the inside wall of the fluid passage, as shown in Fig. 14.

5 The fluid passage 160 is sufficiently large to allow the first substance 154 to flow around the mid seal and into the second chamber 156 where it is mixed with the second substance 158. Once the first component is completely transferred to the second chamber 156, the plunger seal 143 is advanced until it abuts the mid seal 170, as shown in Fig. 15. The combined
10 axial length of the mid seal 170 and piston 143 is slightly longer than the length of the fluid passage 160. Therefore, the mid seal and piston seal off the entire length of the fluid passage. This prevents the contents of the second chamber 156 from backflowing during mixing of the components.

15 After mixing of the components is completed, the locking clip 200 is removed to allow injection of the medication into the patient. Pressure is applied to the cartridge 150 to discharge the medication from the second chamber 156. At the completion of the injection stroke, the cartridge 150 actuates the needle retainer 120. Pressure on the cartridge 150 is then released so that the needle can be retracted, as shown in Fig. 16.

20 Referring now to Figs. 17-23 in general, and to Fig. 17 specifically, another embodiment of a pre-filled safety diluent injector is designated generally 210. The injector device 210 includes a double-ended needle 212, a generally cylindrical barrel 230 that houses the needle and a generally cylindrical cartridge 250. The barrel 230 further includes a compression spring 226 and a needle retainer 220 releasably retaining the needle 212 against the bias of the spring. The needle 212 has a sharpened rearward tip 214 and a sharpened forward tip 216. The spring 226 circumscribes the needle 212 and is compressed against the interior of the barrel 230 at the barrel's forward end. The rearward end of the spring 226

bears against the interior of the needle retainer 220 to bias the needle 212 and needle retainer in the rearward direction.

In this embodiment, the transferring and mixing of the
5 medication components is done in the cartridge 250 prior to attaching the cartridge to the needle hub 221. Since the cartridge 250 is not connected to the needle assembly during mixing, there is no risk of inadvertently retracting the needle during the mixture of the components. As a result, the barrel does not include a locking clip, as in the other embodiments.

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Referring now to Figs. 18-19, the cartridge 250 and barrel 230 are packaged and distributed so that the two are disassembled. The cartridge 250 is a generally cylindrical vessel that may be molded out of pharmaceutical quality glass such as borosilicate or a rigid inert plastic such as polyolefin or polyester. A cartridge cap 253 is disposed over the distal end of the cartridge 250. The cartridge 250 is configured similar to the cartridge 150 illustrated in Figs. 12 - 16, and includes a bubble-like fluid passage 260 that protrudes outwardly from the side of the cartridge. A mid seal 270 is slidably disposed in the cartridge 250 and divides the cartridge into a first chamber 252 and a second chamber 256. Each chamber of cartridge 250 is filled with a predetermined amount of a component of medication during manufacturing of the device 210. In particular, the first chamber 252 is prefilled with a first component 254 of the medication and the second chamber 256 is prefilled with a second component 258.

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Referring now to Fig. 20, a plunger 240 is slidably disposed in the proximal end of the cartridge 250. The plunger 240 is comprised of a plastic molded plunger rod 241 and an elastomeric plunger seal 243. When the plunger 240 is axially advanced into the cartridge 250, the first component 254 is compressed against the rearward end of the mid seal 270 in the first chamber 252. As back pressure on the mid seal 270 overcomes the frictional

resistance between the mid seal and the cartridge **250**, the mid seal is displaced forwardly in the cartridge. Once the mid seal **270** is displaced into alignment with the fluid passage **260**, a passage is created between the mid seal and the inside wall of the fluid passage to allow the first substance **254** to flow around the mid seal and into the second chamber **256** where it is mixed with the second substance **258**.

The fluid passage **260** is sufficiently long to allow the first substance **254** to flow around the mid seal and into the second chamber **256** where it is mixed with the second substance **258**. Once the first component is completely transferred to the second chamber **256**, the plunger seal **243** is advanced until it abuts the mid seal **270**, as shown in Fig. 21. The combined axial length of the mid seal **270** and plunger seal **243** is slightly longer than the maximum length of the fluid passage **260** so that the mid seal and plunger seal close off the entire length of the fluid passage. This prevents the contents of the second chamber **256** from backflowing during mixing of the components.

Referring again to Fig. 18, the cartridge **250** includes an elastomeric front seal **280** in the distal end of the cartridge. The front seal **280** may be molded of a self-sealing biocompatible elastomer such as polyisoprene. The front seal **280** is generally cylindrical with a wide cylindrical rearward end **282** disposed within the cartridge and a reduced diameter forward end **284** projecting forwardly from the forward end of the cartridge. The rearward end **282** has an outside diameter that is similar to the inside diameter of the cartridge **250**. In addition, the rearward end **282** has a plurality of axially-spaced circumferential ribs **286** that frictionally and sealingly engage the interior of the cartridge to provide a fluid tight seal and prevent fluid from leaking from the cartridge.

The forward end **284** of front seal **280** includes an external

thread **288** about its circumference. The distal end **284** also contains a shallow frontal cavity **290**. A narrow bore **292** in fluid connection with the second chamber **256** extends from the proximal end of the front seal **280** and terminates within the reduced diameter distal end **284**. Fluid communication
5 between the frontal cavity **290** and the bore **292** is obstructed by a pierceable membrane **294**.

Referring now to Fig. 19, the barrel **230** is generally cylindrical and has a tapered nose **232** at its distal end. The nose **232** has an opening through which the needle **212** extends. In addition, the nose **232** is configured to receive a needle cover **211** that fits over the nose to prevent accidental needle sticks when the needle **212** is in an extended position. The proximal end of the barrel **230** is open, forming a cylindrical socket **234** adapted to receive the cartridge **250**. Prior to attachment with the cartridge
10 **250**, the rearward open end of the barrel **230** is closed by a cylindrical barrel cap **233**. The barrel further includes a pair of retaining apertures **238** that cooperate with the needle retainer **220** to releasably retain the needle, and a pair of lockout windows that cooperate with locking tabs to lock the needle in
15 the retracted position.

The needle retainer **220** includes a generally cylindrical body **221** and a pair of retaining arms **222** that extend radially forwardly from the body **221**. A generally cylindrical aperture **296** is disposed within the proximal end of the needle retainer body **221**. The inner wall of the aperture **296**
20 includes internal screw threads **298** that are adapted to receive the external screw thread **288** of the front seal **280** in the cartridge **250**.

The cartridge cap **253** and barrel cap **233** are removed from the cartridge **250** and barrel **230**, respectively, to prepare the cartridge and barrel for assembly. The cartridge **250** is connected to the barrel **230** by inserting
25 the forward end of the front seal through the open end of the barrel **230** and

screwing the cartridge clockwise into the aperture **296**. The frontal cavity **290** in the front seal **280** is preferably coaxial with the needle **212**, such that attachment of the cartridge **250** to the barrel **230** causes the proximal needle tip **214** to enter the cavity **290** and pierce the membrane **294**, thereby
5 connecting the second chamber of the cartridge in fluid communication with the needle **212**, as shown in Fig. 17.

Referring to Fig. 17, the cartridge **250** is connected to the barrel **230**, the medication can be injected into the patient by advancing the
10 cartridge forwardly into the barrel. The proximal end of the front seal **280** is configured to form a sliding fit with the interior of the cartridge **250** so that the cartridge slides over the front seal during advancement of the cartridge. As the cartridge **250** is advanced, the rearward end of the front seal **280** bears against the needle retainer **220**, thereby keeping the front seal stationary
15 during advancement of the cartridge. At the same time, the mid seal **270** at the rear of the second chamber **256** is displaced toward the front seal **280**. This causes a reduction of volume in the second chamber **256**, whereby the
20 medication is displaced into the needle to facilitate the injection. At the completion of the injection, the mid seal **270** bears against the rearward end of the front seal **280**, as shown in Fig. 22.

As in the previous embodiments, the needle **212** is retracted by actuating the needle retainer **220**. In particular, the needle **212** is retracted by disengaging the retaining arms **222** from the retaining apertures **238** in the
25 barrel wall to allow the spring **226** to propel the needle **212** rearwardly. To actuate the needle retainer **220**, pressure is applied to the cartridge **250** to advance the cartridge over the needle retainer body **221**, as shown in Fig. 22. During advancement, the distal end of the cartridge **250** engages a cylindrical sleeve **300** that is disposed around the distal end of the needle retainer body
30 **221**. The inside and outside diameters of the release sleeve **300** are preferably equal to the inside and outside diameters of the cartridge **250** so

that the distal end of the cartridge mates with the proximal end of the sleeve. Prior to engagement with the cartridge **250**, axial movement of the release sleeve **300** along the needle retainer is limited by an internal flange **302** that slides within an annular fluid passage **223** on the needle retainer body **221**.

5 After the cartridge **250** engages the sleeve **300** continued advancement of the cartridge drives the sleeve axially forwardly into engagement with the retaining arms **222**. The release sleeve **300** deflects the retaining arms radially inwardly and out of engagement with the retaining apertures **238**, allowing the spring **226** to propel the needle **212** rearwardly, as shown in Fig.

10 23.

As described above, the third embodiment includes a threaded engagement between the front seal **280** and the needle retainer **220** rather than a barbed connection as described in the first two embodiments. Using a threaded connection can increase the overall length of the needle retainer **220**, which in turn increases the distance between the distal end of the cartridge **250** and the retaining arms **222**. One manner for accommodating this increased length is to increase the length of the barrel **230**. However, by incorporating the release sleeve **300**, the length of the barrel **230** need not be substantially increased. The release sleeve **300** compensates for the increased distance by acting as an extension of the cartridge **250**. This eliminates the need to increase the overall length of the device **210**. Preferably, the length of the release sleeve **300** is slightly longer than the length of the threaded engagement between the front seal **280** and the needle retainer **220**.

Referring now to Figs. 24-29 in general, and to Figs. 24-25 specifically, a fourth embodiment of a pre-filled safety diluent injector is shown. The injector device **310** includes a double-ended needle **312**, a generally cylindrical barrel **330** that houses the needle and a generally cylindrical cartridge assembly **350** mounted within the proximal end of the

barrel. Like the previous embodiments, the barrel further includes a compression spring 326 and a needle retainer 320 releasably retaining the needle 312 against the bias of the spring. The device 310 also includes a U-shaped locking clip 400 in the barrel wall to prevent accidental discharge of
5 medication from the device 310.

The cartridge assembly 350 has a two-part design that offers the advantage of using cost-efficient plastic in the assembly. The cartridge assembly 350 includes a front cylinder 351 having an open proximal end and a rear cylinder 353 having an open distal end telescopically mounted to the proximal end of the front cylinder. The front cylinder 351 contains an internal wall 360 that divides the cartridge assembly 350 into a first chamber 352 and a second chamber 356. The first chamber 352 contains a predetermined amount of a first component 354 of medication, and the second chamber 356 contains a predetermined amount of a second component 358 of medication.
10 The proximal end of the front cylinder 351 is closed by a pierceable elastomeric front seal 380.
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In many applications, the second component 358 will be a dry powdered component. Dry components do not require a glass container and can be stored in plastic containers without jeopardizing long term stability of the component. Since it is more cost-efficient to mold complex parts out of plastic than glass, it is preferable to minimize the complexity of the glass portion of the cartridge assembly 350. To this end, the front and rear cylinders 351, 353 are configured so that the first component 354 is stored entirely within the rear cylinder and the second component 356 is stored entirely within the front cylinder. In this arrangement, the front cylinder 351 comprises a more complicated structure to allow the rear cylinder to be a simple cup-shaped container. Therefore, the more complex forward cylinder
20 can be molded out of cost-efficient plastic for those devices that store a dry second component 358 in the second chamber 356. Preferably, glass is only
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used, if at all, to mold the rear cylinder 353.

As stated earlier, the rear cylinder 353 is telescopically mounted on the proximal end of the front cylinder 351. The outside diameter of the rear portion of the rear seal is generally equal to the inside diameter of the rear cylinder 353 so as to frictionally engage the interior of the rear cylinder and provide a fluid tight seal. The rear cylinder 353 is adapted to slide axially over the rear seal 340 in response to pressure applied to the proximal end of the rear cylinder.

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The barrel 330 has an inside diameter large enough to accommodate the outside diameter of the rear cylinder 353. As a result, the outside wall of the front cylinder 351 is separated from the interior wall of barrel 330 by a clearance space, as shown in Fig. 25. The front cylinder 351 is maintained in a concentric relationship with the much larger barrel 330 by a pair of opposing longitudinal ribs 355 on the outside wall of the front cylinder. The longitudinal ribs are illustrated in Fig. 24.

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An elastomeric rear seal 340 is disposed between the front cylinder 351 and rear cylinder 353. The rear seal 340 includes a reduced diameter end 342 partially disposed in the open proximal end of the front cylinder 351. The rear seal 340 also includes a flanged end 344 disposed within the rear cylinder 353. The reduced diameter end 342 and flanged end 344 frictionally and sealingly engage the interior of the front cylinder 352 and rear cylinder 354, respectively. This engagement provides a fluid tight seal with the interior of both cylinders, while allowing the rear seal 340 to be displaced relative to either cylinder. Forward advancement of the rear seal 340 relative to the front cylinder 351 is limited by the proximal end of the front cylinder, which is configured to matingly engage the flanged portion of the rear seal.

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As stated earlier, the front cylinder 351 contains an internal wall 360. The internal wall 360 is adjacent the rearward open end of the cartridge, forming a socket for receiving the rear seal 340. The internal wall 360 contains an orifice 362 mounted in the center of the wall 360. A hollow piercing member 364 is mounted in the orifice and extends rearwardly toward the rear seal 340. In addition, it may be desirable to provide a vent opening in the internal wall 360 to vent the air between the rear seal 340 and the internal wall when the rear cylinder is advanced to pierce the rear seal.

10 The distal end of the rear seal 340 is closed by a membrane 348 that is configured to be pierced by piercing member 364. The rear seal 340 includes a hollowed mid section 346 that is connected in fluid communication with the first chamber 352 through the proximal end of the rear seal. Once the membrane 348 is pierced, a fluid passage is created through the piercing member 364 and rear seal 340, such that the first and second chambers, 352, 356 are connected in fluid communication. The rear seal 340 may be molded in a high elongation self-sealing biocompatible elastomer, such as polyisoprene.

20 The operation of the device 310 will now be described. A slight squeezing pressure is applied to the proximal end of the rear cylinder 353 to axially advance the rear cylinder over the front cylinder 351. This causes the first component 354 to become compressed between the rear seal 340 and the closed proximal end of the rear cylinder 353. Continued pressure on the rear cylinder 353 creates back pressure on the rear seal 340 which axially displaces the rear seal forwardly into the piercing member 364. At this time, the membrane 348 is pierced to create a fluid passage between the first and second chambers 352, 356.

30 The rear cylinder 353 is advanced forwardly relative to the front cylinder 351 to expel the first component 354 from the first chamber 352 into

the second chamber **356**. Once the first component **354** is completely expelled from the first chamber **352**, additional pressure on the rear cylinder **353** advances the rear cylinder forwardly relative to the front cylinder **351** until the closed proximal end of the rear cylinder abuts the proximal end of the rear seal **340**, as shown in Fig. 26. At this point, the device **310** is shaken to mix the components within the second chamber **356**. During the mixing process, displacement of the cartridge assembly **350** is prevented by the locking clip **400**, thereby minimizing the potential for accidental discharge of the medication.

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After the components are mixed, the locking clip **400** is removed. The cartridge assembly is then displaced forwardly so that the rearward end of the needle **312** pierces the forward seal **380**. The air is then vented from the forward chamber. Further pressure is applied to the cartridge assembly **350** to discharge the medication from the second chamber **356** and through the needle **312**. At the completion of the injection stroke, the proximal end of the cartridge assembly **350** actuates the needle retainer **320**, as shown in Fig. 27. Pressure on the cartridge assembly **350** is then released so that the needle **312** can be retracted, as shown in Figs. 28 and 29.

In some instances, it may be desirable to store the cartridge in its component parts. In other words, the rear cylinder **353** may be detached from the forward cylinder **351**. Prior to use, the rear cylinder **353** would be attached to the forward cylinder **351** and the combined assembly would be utilized as described above. In such instances, the separate rear container **353** may include a separate cap to cover its forward end. Similarly, the forward cylinder **351** may include a cap to cover its rearward end. The detachable rearward cylinder **353** may permit a variety of pre-measured medicinal components to be stored and readily combined in various combinations prior to use.

The terms and expressions which have been employed are used as terms of description and not of limitation. There is no intention in use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof. It is recognized, however, that
5 various modifications of the embodiments described herein are possible within the scope and spirit of the invention. For instance, the embodiments described above include a needle retainer having a pair of radially displaceable arms to automatically release the needle for retraction after use. However, the devices may be modified by utilizing different needle retainers
10 that may or may not automatically retract the needle after use. Accordingly, the invention incorporates variations that fall within the scope of the following claims.

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